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# STUDY OF THE RHEOLOGICAL PROPERTIES OF MYOSIN-PLANT PROTEIN SYSTEMS DURING THERMOTROPIC GELATION

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## Abstract

Model systems containing myosin mixed with native and slightly preheated plant protein preparations (soy glycinin, sunflower seed protein isolate, wheat gluten, wheat gliadin and wheat glutenin) and experimental sausages from beef meat and added protein preparations were studied after heat treatment for textural properties using an Instron 1140 apparatus.

All non-meat preparations caused decrease in cohesivity and elasticity except glutenin. Vital gluten and soy glicinin had some advantages in comparison to sunflower seed protein.

Preheating of gluten for 30 and 45 minutes resulted in significant increase in hardness and chewiness but not in elasticity. Preheating of soy glycinin for 45 minutes caused significant changes in work of compression, elasticity and chewiness.

*Keywords:* myosin, plant protein isolates, thermal gelation, myosin–plant protein interaction.

## 1. Introduction

Non-meat proteins derived from a variety of plant sources are extensively used as fillers, binders and extenders in meat systems [1]. A lot of specific sausages or similar products are produced using non-meat proteins as additives.

It is typical for such type of products that they have a considerable amount of fat, which must be uniformly distributed in the mass of the product. Concerning the texture it is generally desired to have a product which would most likely cut with a knife. The concept of restructuring meat and poultry products has come into wide use in the past decade. Research and development work was conducted in many laboratories. The word restructuring as it is used with respect to red meat and poultry meat refers to taking the raw material – the soft tissues, including lean, fat and connective tissue – and change their colloidal properties, texture of chopped components and form.

This restructuring adds value and can upgrade raw materials, which would not normally be a part of steak-like product. These raw materials are typically used for ground meat systems.

In the last period considerable interest has developed in Hungary in restructuring poultry products because the processing can increase the value of specific primal outs, utilize lean timings and produce specific new products [2]. The processing can also tailor the composition of products to consumer specific needs. From this point the composition of raw materials is the most important. The most problematic is the fat content. From one side fat is a major contributor to juiciness and flavor of finished meat products. Complaints about dry and tasteless product can often be corrected with closer attention to fat content. There is also the economic implication of formulating to higher fat contents. From the other side there is a pressure to reduce the fat content. Nevertheless, it is true that through formulation a consistent fat content and thus a consistent texture are to be easier obtained in restructured products than in the intact muscle products with lowered fat levels.

Gelation during thermal processing of meat products and consequently the stabilization of fat and water as well as binding meat particles together is mainly connected with the myosin protein of muscle tissue [3].

Although the influence of non-meat proteins on thermal gelation and properties of endproduct has been studied by several researchers [5]–[9] the elucidation of mechanism of gelation at molecular level and finding a commercially acceptable way to improve the quality of endproducts needs further investigations. It seems that the prerequisite of the formation of a mixed gel with practically the same textural properties as the pure myosin gel is the adequate interaction between two types of denaturated proteins. This prerequisite is named by some authors: structural compatibility [10]. Studies concerning denaturation processes showed that the denaturation temperature (and the temperature of aggregation) is different for proteins used. E.g. as reported [11], [12], the denaturation of myosin starts at about 50 °C and that of soy 11S protein starts at much higher temperatures [7]. We supposed that a synchronization of denaturation processes by limited thermal treatment of protein components using high temperature of denaturation will contribute to a better interaction of added proteins with myosin and so reduce the negative effect on textural properties of products.

In this paper the results of studies using raw and heat treated plant protein isolates are summarized.

## 2. Materials and Methods

Soy glycinin prepared according to OKUBO et al., [13], sunflower seed globulin preparations [14], commercial vital gluten preparation, wheat glutenin and wheat gliadin prepared by Osborne's procedure and myosin (according to WANG et al., [15]) were used in model experiments.

Preheated protein samples were prepared by heating at 80 °C for 10, 20, 30 and 45 minutes.

In model experiments a suspension containing 2.2 g myosin, 0.5 g sodium chloride, 0.05 g $Na_2P_2O_7$ and 7.25 g water was prepared and filled in test tubes

(26 mm Ø, 12 mm height). To study the effect of plant protein preparation in the suspension mentioned above 0.2 g, 0.4 g and 0.6 g of myosin resp. actomyosin were substituted by glycinin, glutenin and sunflower seed globulin.

*Table 1.* Textural properties of the model systems

| Sample | Myosin | Acto-myosin | Myosin-gliadin | Myosin-vital gluten | Myosin-glycinin | Myosin-sunflower seed globulin |
|---|---|---|---|---|---|---|
| Work of 1-st compression ($A_2/mm^2$) | 1350 | 1180 | $1220^1$<br>$1170^2$<br>$1040^3$ | ***1310***$^1$<br>$1290^2$<br>$1270^3$ | $1210^1$<br>$1150^2$<br>$1030^3$ | $1150^1$<br>$1030^2$<br>$970^3$ |
| Work of 2-nd compression ($A_2/mm^2$) | 240 | 210 | $205^1$<br>$195^2$<br>$190^3$ | $190^1$<br>$185^2$<br>$176^3$ | $187^1$<br>$179^2$<br>$172^3$ | $185^1$<br>$175^2$<br>$169^3$ |
| Hardness (H) | 73.4 | 73.3 | $60^1$<br>$58^2$<br>$55^3$ | ***72.5***$^1$<br>***71.5***$^2$<br>$70.2^3$ | $69.5^1$<br>$68.2^2$<br>$67.9^3$ | $64.2^1$<br>$63.8^2$<br>$61.9^3$ |
| Elasticity (E) | 22.0 | 16.0 | $18.0^1$<br>$16.0^2$<br>$13.0^3$ | ***20.2***$^1$<br>$19.3^2$<br>$18.8^3$ | $17.9^1$<br>$17.5^2$<br>$16.8^3$ | $17.6^1$<br>$17.3^2$<br>$16.5^3$ |
| Cohesivity (C) ($A_2/A_1$) | 0.180 | 0.178 | $0.1682^1$<br>$0.166^2$<br>$0.182^3$ | $0.145^1$<br>$0.143^2$<br>$0.137^3$ | $0.154^1$<br>$0.155^2$<br>$0.166^3$ | $0.160^1$<br>$0.169^2$<br>$0.17^3$ |
| Gumminess (B) (C x H) | 13.2 | 13.0 | $10.08^1$<br>$9.628^2$<br>$10.01^3$ | $10.51^1$<br>$10.25^2$<br>$19.61^3$ | $10.703^1$<br>$10.571^2$<br>$11.27^3$ | $10.272^1$<br>$10.78^2$<br>$10.77^3$ |
| Chewiness (Ch) (G x E) | 190.6 | 208.7 | $181.44^1$<br>$154.048^2$<br>$130.13^3$ | $212.302^1$<br>$197.825^2$<br>$180.668^3$ | $191.58^1$<br>$184.99^2$<br>$189.336^3$ | $180.78^1$<br>$186.494^2$<br>$177.705^3$ |

The data written in bold leters are not significantly different from those of myosin.
$^1$2.0 g myosin + 0.2 g added protein
$^2$1.8 g myosin + 0.4 g added protein
$^3$1.6 g myosin + 0.6 g added protein

The suspensions were heated at 80 °C for 40 minutes. Sausages were prepared according to the following recipe:

Beef meat 95.5. g, fat 40.0. g, NaCl 3.6 g, nitrite 0.2 g
$Na_2P_2O_7$0.6 g, water 59.6 g

To study the effect of plant protein preparations 2.0 g of the meat protein were substituted with soy isolate, sunflower seed isolate and vital gluten resp.

For the characterization of textural properties of the model system the test pieces (26 mm Ø, 12 mm height) were tested in an Instron Type 1140 apparatus using double-compression test with constant rate (25 %) of deformation. Three repetitions were made and the texture profile curves were evaluated. The surface hydrophobicity of meat protein preparations was determined using 1-anilinonaftalen-8-sulfonic acid and hydrophobicity of gluten proteins and sunflower seed globulin using alfa-p-toluidinyl-naftalene-6-sulfonate [16]. Sulfhydryl content of protein preparations was determined amperometrically [17].

## 3. Results and Discussion

The results of the measurement of textural properties of model systems are summarized in *Table 1*. On the basis of the data included in the table it can be stated that the sample containing only myosin as protein component possesses the best textural properties. Substitution of myosin with other proteins always results to a smaller or greater extent in a decrease especially in hardness and elasticity but changes in cohesivity are small. Glutenin results in a practically unchanged hardness and elasticity. The substitution of a part of myosin with soy glycinin and sunflower seed globulin results in a slight decrease in textural parameters. The trend of changes is very similar and slight advantage of glycinin may be observed in comparison with globulin of sunflower seed.

Preliminary results suggest that no significant effect of quantity of sulfhydryl groups on the textural properties may be observed. Desamination of gliadin caused only slight decrease in cohesivity and hardness of samples. The results suggest the conclusion that the role of disulfide and hydrogen bonds is limited in the formation of gel during heat treatment. Although the differences in hydrophobicity are not too big among different protein preparations, nevertheless the role of hydrophobic interactions might be the most important. The denaturation of the proteins and structural changes probably increase the number of apolar groups being able to interact.

In *Table 2* textural parameters of sausages prepared with addition of different protein preparations are shown. Myosin addition resulted in slight improvement of the textural properties as seen from the data included in the table. A decrease of textural quality of product was observed in the case of other protein preparations. Soy isolate was relatively the best extender.

In *Table 3* the textural properties of model systems prepared with preheated soy glycinin and vital gluten are shown. In the case of glycinin only the preheating for 45 minutes caused significant changes in work of compression, elasticity and chewiness. Preheating of gluten for 30 or 45 minutes resulted in significant increase in hardness and chewiness but not in elasticity.

The data obtained with preheated soy protein may be explained by the obser-

*Table 2.* Textural properties of sausages prepared with addition of different protein preparations

| Sample | Control | Control + soy isolate | Control + sunflower seed isolate | Control + vital gluten | Control + myosin |
|---|---|---|---|---|---|
| Work of 1-st compression ($A_2$/mm$^2$) | 1192 | 1135 | 970 | 950 | ***1220*** |
| Work of 2-nd compression ($A_2$/mm$^2$) | 202 | 170 | 160 | 150 | ***205*** |
| Hardness (H) | 73.3 | 68.6 | 70.0 | 60.0 | 70.0 |
| Elasticity (E) | 15.0 | 15.0 | 13.5 | 15.0 | 18.0 |
| Cohesivity (C) ($A_2/A_1$) | 0.178 | 0.164 | 0.165 | 0.157 | 0.168 |
| Gumminess (B) (C x H) | 13.04 | 11.27 | 11.55 | 9.47 | 11.76 |
| Chewiness (Ch) (G x E) | 195.6 | 169.0 | 155.9 | 142.1 | 211.68 |

The data written in bold letters are not significantly different from control data.

vation of PENG et al., [7] that only basic subunits of glycinin interact significantly with myosin. For dissociation of glycinin subunits a longer period of heat treatment is needed and so only the preheating of 45 minutes has some effect on textural properties.

*Table 3.* Textural properties of models prepared with preheated glycinin and vital gluten (1.8 g myosin + 0.4 g added protein)

| Characteristic | Myosin + Glycinin | | | | Myosin + Vital gluten | | | |
|---|---|---|---|---|---|---|---|---|
| | Native | Preheated | | | Native | Preheated | | |
| | glycinin | 15 min | 30 min | 45 min | vital gluten | 15 min | 30 min | 45 min |
| Work of 1-st compression ($A_1/mm^2$) | 1130 | 1120 | 1142 | ***1220*** | 1310 | 1330 | 1370 | 1290 |
| Work of 2-nd compression ($A_1/mm^2$) | 189 | 176 | 187 | ***203*** | 235 | 229 | 237 | 208 |
| Hardness (H) | 71.0 | 72.1 | 69.0 | 73.1 | 73.0 | 72.6 | ***76.2*** | ***76.1*** |
| Elasticity (E) | 20.1 | 20.3 | 20.8 | ***22.4*** | 21.4 | 20.8 | 22.1 | 19.6 |
| Cohesivity (C) ($A_2/A_1$) | 0.166 | 0.157 | 0.164 | 0.166 | 0.179 | 0.172 | 0.173 | 0.161 |
| Gumminess (B) (C x H) | 11.8 | 11.3 | 11.3 | 12.13 | 13.0 | 12.5 | 13.2 | 12.3 |
| Chewiness (Ch) (G x E) | 237.2 | 229.4 | 235.0 | ***271.7*** | 278.0 | 260.0 | ***291.7*** | ***241.1*** |

The data written in bold letters are significantly higher than the control values.

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